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THE SEAWEEDS OF HAWAII

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"The Hawaiians, like the Japanese, are fond of almost all the products of the sea, and, like them, prize the seaweed very highly for food. Ancient Hawaiians probably seldom ate a meal without some kind of *limu* or seaweed. . . ."—Reed.

The Hawaiian Archipelago is about two thousand miles long, and lies athwart the center of the north Pacific ocean. Vast and deep marine expanses isolate it from both the American and the Asiatic continents. The waters that wash its thousand miles of diversified coast line are not tropic, but moderately warm—sub-tropic. Hence its coral reefs are small as compared with the great reefs of the South Pacific. Its seaweeds do not exhibit the profusion of species nor the luxuriance of form and color that characterize the oceanic flora of strictly tropical regions. Moreover, the giant kelps and laminarias that dominate the long cold coasts of northwestern America are conspicuously absent from Hawaiian shores and reefs.

The Hawaiian Islands rise abruptly from abyssal depths. Many of the shore-lines are exceedingly precipitous. Certain geologists have compared the islands to the summits of a row of obelisks. The area of shallow water is much more circumscribed than is generally supposed. The tracts possessing life-conditions favorable for the development of marine algae are distinctly limited in area and localized in distribution. The lower, older islands to the northwest have the largest reefs and shallows. These areas become progressively smaller toward the high, young, volcanic islands of the southeast. The island of Hawaii, youngest member of the archipelago, is distinguished by an almost entire absence of low beachlands, reefs, lagoons, or shallows. These topographic conditions have profoundly influenced the algal and other marine life of the Hawaiian group.

An hour's cruise in an outrigger canoe over a typical fringing reef is sufficient to reveal the five main zones of the algal flora. The shallow in-shore waters, with a bottom of coral sand or mud, sustain a number of the quiet water forms. Partially exposed rock masses of coral or lava are scattered here and there along the beach and in the shallow water. These rocks are horizontally banded with hydroid and algal colonies. Further out there are numerous "pockets" or cup-like depressions in the lagoon floor. These vary in size from a meter in depth and diameter to large pools five or ten meters in depth and diameter. These pockets are easily marked by the darker tint of their water. In them live a variety of organisms that prefer these shadowy havens to the exposure of the shallows or the surf-smitten outer reef.

The next zone is one of deeper water, where wading is no longer possible. The sunny, transparent water is three to ten meters deep, but becomes shallower as the edge of the reef is approached. On the outer rim pound eternally the long rollers of the Pacific, with iridescent spray haze and the deep-toned roar of the surf. Beyond this rim the reef drops abruptly in the abyssal waters of the Pacific. These five zones—shallows, rocks, pools, rim, and outer face of reef—each have distinctive combinations of ecologic factors, and each supports a distinctive flora and fauna.

Several hundred species of marine algae, exclusive of microscopic and unicellular forms, have been collected in Hawaiian waters. These represent a wide range of genera—green, blue-green, brown and red groups—and of habitats. Many species are as yet undescribed and await taxonomic investigation. Among the better represented genera are: Codium, Padina, Halimeda, Dictyota, Turbinaria, Ectocarpus, Enteromorpha, Bryopsis, Caulerpa, Laurencia, Gelidium, Griffithsia, Haliseris, Sargassum, Hypnea, Ulva, Polysiphonia, Porphyra, Hydrodictyon, Gracilaria and Ceramium.

Of great significance as reef builders are the coralline algae or nullipores. There are a number of species that inhabit the shallow waters, forming beautiful purple and lavender incrustations; others occur at considerable depths. The Hawaiian reefs, like those of other regions, undoubtedly owe a considerable proportion of their structure to plant depositions.

Many of the marine algae occupied places of prominence in the dietary of the ancient Hawaiians, and still constitute a staple in the native food. The villages, like those of other parts of Polynesia, were almost universally situated on or near the seashore. The ancient Hawaiians were preeminently a maritime people. They were intimately familiar with the products of the sea. A large part of the population was more or less habitually engaged in fishing. The deep sea fishing was naturally the work of the men, as it involved protracted labor and a certain degree of hazard. The reef-fishing was enjoyed alike by men, women, and children. From the lagoons and shallower waters was obtained a wide variety of marine edibles—fish of many kinds, crabs, crayfish and shrimps, molluscs, holothurians, sea urchins, octopi, etc. The edible seaweeds, *limu,* formed an important element in this native exploitation of the shallow waters.

Doubtless no primitive people made more extensive use of marine products than did the Polynesian in his sea-girt island world. About seventy-five species were used for food, and for these the ancient Hawaiian had specific names. It is of distinct interest to note that the Japanese, whose commercialized seaweed industries have been so widely described and studied, have a small number of edible species as compared with the Hawaiian. In Smith's monumental report on the Seaweed Industries of Japan (U. S. Bureau of Fisheries), only thirty-five species are reported as used for food, and ten others for the manufacture of gelatine, glue, iodin, etc. Thus the Hawaiian marine flora, although relatively poor in quantity, is rich in economic species.

The generic name for all kinds of algae was *limu*; to this was added in true Linnaean spirit, one or more descriptive terms. This is a truly noteworthy instance of parallelism in the evolution of nomenclature. The botanical nomenclature familiar to every learned Hawaiian of the old regime was essentially identical with the binomial system evolved by Caucasian scientists. The following examples of the old names for seaweeds will serve to elucidate this point:

Limu ele-ele ("the black or dark limu"), *Enteromorpha flexuosa.*
Limu lo-loa ("the long or slender limu"), *Gelidium* sp.
Limu koele ("the dry or hard limu"), *Gymnogongrus* sp.
Limu wawae-iole ("the mouse-foot limu"), *Codium muelleri.*
Limu huna ("the concealed or hidden limu"), *Hypnea* sp.
Limu koko ("the red limu"), *Asparagopsis sanfordiana.*

The *limu* was collected in various ways, depending upon the nature of the habitat. Some kinds (Sargassum, Gracilaria) drift ashore in tolerable abundance, and were easily gathered. Others growing in the quiet shore waters (Ulva, Entermorpha, Chondria, etc.) were readily collected by the older women and the children. Others, with stout stems and hold-fasts, occupied the black lava rocks in rough water. They were exposed to continuous surf-pounding and could only be collected by skilful swimmers, the men and younger women. A sharp stone or chisel was used to separate these *limu* from their rocky substratum. Gelidium and Porphyra belong to this class. A fourth class (Gymnogongrus, Dictyota, etc.) inhabited the outer edge of the reef, where the heavy rollers break. These were usually gathered by the men in outrigger canoes. A few species (e. g, *Porphyra leucostica*) occur only in certain restricted localities, or during brief seasons. These were either pre-empted by the chiefs as choice delicacies befitting nobility alone, or were consumed locally, and were not in general use among the people.

It is interesting to note that the Hawaiians anticipated by many centuries some of the recently advocated plans of limnologists for cultivating aquatic vegetation of economic value. A crude form of *limu* culture was practiced by the Hawaiian nobility in olden time. Rare and choice varieties were transplanted to the vicinity of the chief's beach home, where they were protected and easily available. Sometimes the fish ponds were thus used as alga-gardens. In these places the other algae were weeded out, and the semi-"cultivated" forms developed much more luxuriantly than they otherwise would have done. An example of one of these ancient royal *limu* gardens occurs near the beach residence of ex-Queen Liliuokalani, at Honolulu.

Since the coming of the white man the collecting of seaweeds has been greatly facilitated by the use of such simple aids as glass-bottomed "water-boxes," and sharpened iron rods. These have been generally adopted by the natives, who quickly perceived their utility. In ancient times the *limu* gatherer was compelled to rely on his unaided vision and a simple stone chisel.

After the *limu* was brought ashore the women took charge of it. They sorted the various kinds into separate piles, washed each in several changes of salt or fresh water. All sand, grit and other inedible matter was thoroughly removed. After cleansing the *limu* was salted and chopped or broken into small fragments. Certain species decayed rapidly if washed in fresh water; these were rinsed in salt water and eaten soon after preparation.

The *limu* was eaten raw, like a salad or relish. It was the universal accompaniment of the fish that formed an essential part of the native diet. Occasionally, when the supply of customary vegetable food (such as taro, sweet potatoes, or yams) fell short, as in times of war or famine, the *limu* was used as a substitute. It was then cooked in the underground oven, *imu*, with the meats.

A number of algae, both marine and fresh-water forms, were customarily treated to a native "ripening" process. This *limu* was soaked in fresh water for twenty-four hours or more, causing partial decomposition and the development of a strong odor. The filamentous algae common in mountain streams were considered to be particularly suitable for "ripening," and were generally used only after this peculiar treatment.

Limu was eaten in combination with many other foods, rather than as a food by itself. It corresponded to the salad, or to the ripe olives and salted almonds, of an American dinner. The finely-chopped *limu* was mixed with any one or with combinations of the following: raw-fish, squid, shrimps, limpets, crabs, sea-urchins, holothurians, *kukui* nuts, chili peppers. A favorite relish was made from the roasted kernels of the *kukui* nuts (*Aleurites moluccana*, or candle-nut), which were chopped fine and mixed with *limu* and salt. According to Miss Reed, who a number of years ago made a careful study of the edible seaweeds of Hawaii, "This will keep for months in glass jars, and is excellent with bread and butter or cold meats. It resembles Russian caviar in flavor. . . . The Hawaiian serve this with poi, raw or cooked fish, or roast meats."

Vegetable preparations of various kinds comprised a large part of the native pharmacopeia. The *limu*, although not an important item in the long list of Hawaiian medicines, were used in several ways. Certain filamentous species (Spirogyra, etc.) were used as poultices for sore eyes. A number of kinds were used as poultices for cuts, bruises, sores, and boils. An infusion of Centroceros was used as a cathartic, and *Hypnea nidifica* was similarly employed for stomach troubles.

The edible seaweeds were so extensively and so variously used in ancient Hawaii that it is difficult to make any accurate estimate of the quantities then consumed. In modern times, despite the great shrinkage of the native population, *limu* forms a staple article of merchandise at the fish markets. In Honolulu, the chief market, the annual sales amount to about five thousand pounds, selling at about $2,500. This comprises chiefly *limu kohu* (*Asparagopsis sanfordiana*), *limu ele-ele* (*Enteromorpha* spp.), and *limu o-olu* (*Chondria tenuissima*). Hawaii's preponderant Oriental population, that now makes over sixty percent of the total, uses large quantities of seaweed. The Japanese import annually about 165,000 pounds, almost wholly from Japan. The Chinese import about 90,000 pounds from their country.

With the passing of the Hawaiian much of the old *limu* lore will be lost. In time, as marine biological stations and facilities for research develop, it will be supplanted by the precise data of modern algology. Hawaii's seaweeds will always be an interesting component of the diversified marine life of this mid-Pacific archipelago.

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